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NUEXCO

MAY 1984 NUMBER 189

Monthly Report on the Nuclear Fuel Market

NUEXCO

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

May 1984 No. 189

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To Our Readers

Nuexco will host a hospitality suite during the International Nuclear Conference sponsored by the Canadian Nuclear Association, Uranium Institute and Canadian Nuclear Society in Saskatoon, Saskatchewan, Canada, June 3–6. The suite will be located in The Holiday Inn. We look forward to seeing you there.

* * *

Included with this Report is a copy of a speech entitled *South Africa's Role in the Uranium Market*, given by Chris I. Von Christierson, Nuexco's representative in the Republic of South Africa, at Nuexco's luncheon during the Atomic Industrial Forum Fuel Cycle Conference in Atlanta on April 2.

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NATURAL URANIUM AND CONVERSION

The **Exchange Value** as of April 30, 1984 is **$17.75** per pound U_3O_8, up $0.75 since last month. The *Current Market Data* section of this Report lists three uranium sales transactions, involving a total of approximately five million pounds U_3O_8, but all three were concluded at the end of 1983. Two involved long-term deliveries and one involved deliveries in the first half of this year.

Active supply of uranium (U_3O_8 and UF_6) for spot and near-term delivery totals **7.4 million** pounds U_3O_8 or equivalent UF_6, up 1.3 million pounds from last month. The corresponding figure for **active demand** is **3.4 million** pounds, down 400 thousand pounds. The spot and near-term **supply-demand ratio** rose to **2.2:1.**

The **Transaction Value** as of April 30, 1984 is **$17.90** per pound U_3O_8, down $1.35 since last month. The current Transaction Value includes 10 transactions involving a total of 2.5 million pounds U_3O_8 or equivalent UF_6 and covers a period of 5 months.

The **Loan Use Charge Rate** as of April 30, 1984 is **6 percent** per annum, unchanged since last month. No uranium loans are reported.

* * *

The Exchange Value rose $0.75 to $17.75 after the aggressive selling that occurred during March largely subsided. The elimination of a substantial quantity of bargain-priced inventory during March, and the subsequent rise in the overall level of offering prices during April, caused discretionary buyers to reassess the market. Most buyers' inquiries during April were aimed at obtaining prices at or below last month's Exchange Value of $17.00. Sellers' offering prices, on the other hand, were in most cases several dollars above that level. As a result, no new near-term uranium sales transactions were concluded during April. A few active sellers appear willing to offer at or below the $18.00 level, however, and their number may increase if buyers continue to exhibit hesitation, or if new bargain-priced inventory enters the market.

Transaction Value Definition

The definition of the Transaction Value has been revised slightly this month to clarify that sales of natural uranium, *including natural* UF_6, may be included in the calculation. The original definition had made reference only to ". . . prices paid for U_3O_8 . . .", thereby implying the exclusion of natural UF_6.

* * *

The **Conversion Value** as of April 30, 1984 is **$0.80** per pound U as UF_6, unchanged since last month. No conversion transactions are reported. Active secondary market supply of conversion services for delivery within three years totals 2.9 million pounds U as UF_6, but *no* active demand is reported.

Active conversion sellers did not have the occasion to alter their offering prices during April. For buyers interested in secondary market conversion services, $0.80 per pound U would be a representative price. However, buyers interested in purchasing concentrates have shown no willingness to pay for the conversion component of natural UF_6, so sellers of natural UF_6 have been offering at prices that assign a zero value to the conversion component. For example, a seller of natural UF_6 wishing to offer at a price equivalent to $17.00 per pound U_3O_8 would price the material at $44.42 per kgU in UF_6.

SECONDARY MARKET ENRICHMENT SERVICES

The secondary market **SWU Values** as of April 30, 1984 are **$105** for **DOE origin** and **FY85 delivery,** up $5 since last month, and **$80** for **non-DOE origin** and delivery within approximately 15 months, unchanged. The *Current Market Data* section of this Report lists four secondary market SWU transactions involving a total of 240 thousand SWUs. Active secondary market supply of enrichment services totals approximately 1.7 million SWUs, up somewhat from last month, while active demand amounts to 625 thousand SWUs, the same level as last month.

* * *

The price rise for DOE origin SWUs can be attributed *not* to a growing firmness in demand, but to the expectation thereof. Current demand is comprised principally of ISC holders and Requirements contract holders that plan to convert to the USEC. DOE permits the former category of buyers, ISC holders, to buy up to 60 percent of their FY85 requirements on the secondary market and permits the latter group to buy up to 30 percent, so the market potential is well known to sellers. Furthermore, several holders of Requirements contracts bought secondary market SWUs for FY84 delivery in anticipation of converting to the USEC, so their high potential as customers for FY85 SWUs is also well known to sellers. In this context, it is important to note that an important part of the anticipated demand comes from those DOE cus-

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tomers in Europe and Asia that plan to convert to the USEC. As a result of this expectation of increased demand, sellers and buyers alike share the expectation of upward pressure on secondary market prices for DOE origin SWUs. Finally, sellers would prefer to wait as long as practical to compete aggressively for the available demand, primarily because that strategy delays the date they will be required to pay the discounts necessary to effect SWU contract assignments. (See page 25 in this Report for an article describing common mechanisms for secondary market SWU transactions.)

* * *

The **non-DOE origin SWU Value** stayed at approximately $80 during April, as non-DOE sellers continued to offer low prices in competition for the business of utilities free to purchase non-DOE SWUs. While the $80 price leve reflects secondary market offering prices, primary market prices for non-DOE SWUs are not considerably higher than that level.

NEW USDOE SWU PRICES

On April 4, 1984, DOE published in the Federal Register its new prices for enrichment services as follows:

1. Utility Services enrichment contracts (USEC): $135.00 per SWU, effective immediately;

2. Fixed-Commitment contracts: $153.00 per SWU, effective October 1, 1984;

3. Requirements contracts: $157.00 per SWU, effective October 1, 1984.

The price increases for enrichment services delivered under Fixed-Commitment and Requirements contracts reflect an extension of DOE's existing pricing policy. This policy assigns risk levels to future sales slippage based on historical comparisons. In theory, a more stable sales base means less risk of slippage and lowers the price increase necessary.

In the latest announcement, DOE assigned a 16-percent risk of slippage to sales under Fixed-Commitment contracts and a 19-percent risk factor to sales under Requirements contracts. DOE views the USEC as providing the most stable sales base.

The risk percentages were calculated by comparing the change between the SWU sales forecast and actual sales made over a specific period. Surcharges were based upon the difference.

The increases in the Fixed-Commitment and Requirements contract prices were generally in line with industry expectations. It had been anticipated that DOE would create a significant price differential between the USEC and the other two types in order to provide an incentive for holders of Fixed-Commitment and Requirements contracts to convert to the USEC. So far it would appear that most contract holders are planning to do so. A few holders of 3.5-year Requirements contracts and some European customers of DOE have indicated that they do not plan to convert now, if ever. In the meantime, Urenco and Eurodif, DOE's European competitors, are making an aggressive push for US market share by offering long-term contracts having terms as favorable as those in the USEC and at significantly lower prices.

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EXCHANGE VALUE $17.75/lb. U_3O_8
Determined as of April 30, 1984

Definition

The Exchange Value is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

Derivation

Nuexco bases the Exchange Value upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.

Comments

Nuexco does not consider the following in determining the Exchange Value:

A. The price of uranium delivered or to be delivered under old contracts.
B. The price of uranium delivered in connection with contract renegotiations or other than arm's length transactions.

TRANSACTION VALUE[1]
Determined as of April 30, 1984

$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
17.90	2.5	10	5

Definition

The Transaction Value is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

A. Transactions closed within the previous three-month period and for which delivery was scheduled within one year of the transaction date;
B. At least ten transactions;
C. Transactions involving a sum total of at least two million pounds U_3O_8 equivalent.

The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars as of the transaction date.

Comments

Nuexco does not consider the following in determining the Transaction Value:

A. The price of uranium delivered in connection with contract renegotiations or other than arm's length transactions.
B. The price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of Exchange Value or any other independent variable.
C. Transactions in which the delivery price is defined in such a way that it cannot currently be determined.

[1] Transaction Values for 1976 through 1981 and their associated parameters (millions of pounds, number of transactions and number of months) are tabulated on pages 31 and 32 of Report 161. The corresponding data for 1982 are tabulated on page 5 of Report 173, and for 1983 on page 5 of Report 186.

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CURRENT MARKET DATA

LOAN USE CHARGE RATE[1] 6%
Determined as of April 30, 1984

Definition

The Loan Use Charge Rate is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

Derivation

Nuexco bases the Loan Use Charge Rate upon:

A. Data from recently completed or pending loan transactions.
B. Rates included in firm proposals to borrow or lend.
C. Rates that potential borrows and lenders have expressed as a willingness to pay or accept, but for which Nuexco is not aware of firm proposals.

[1]Monthly data for 1968 through 1981 appear on pages 32-34 of Report 162. Monthly data for 1982 appear on page 2 of Report 173.

CONVERSION VALUE $0.80/lb. U as UF_6
Determined as of April 30, 1984

Definition

The Conversion Value is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

Derivation

Nuexco bases the Conversion Value upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.

Comments

Nuexco does not consider the following in determining the Conversion Value:

A. The price of conversion services delivered or to be delivered under old contracts.
B. The price of conversion services delivered in connection with contract renegotiations or other than arm's length transactions.
C. Transportation charges other than those customarily provided by primary suppliers of conversion services.

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SWU VALUES

$105/SWU FOR DOE ORIGIN AND FY85 DELIVERY
$80/SWU FOR NON-DOE ORIGIN AND DELIVERY WITHIN 15 MONTHS
Determined as of April 30, 1984

Definition

The SWU (Separative Work Unit) Values represent Nuexco's judgment of the price, expressed in US dollars per SWU, at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.

Derivation

Nuexco bases the SWU Values upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.
E. SWU prices at varying tails assays and varying product assays are converted to the equivalent SWU price at the DOE Reference Transaction Tails Assay (presently 0.20 weight percent U_{235}) and a product assay of 3.0 weight percent U_{235} assuming feed costs calculated using the Nuexco Exchange Value and Nuexco Conversion Value determined as of the last day of the same month.

Comments

Nuexco does not consider the following in determining the SWU Values:

A. The price of SWUs delivered under long-term contracts from primary suppliers, such as DOE, Urenco, or Eurodif.
B. The price of SWUs delivered under other than arm's length transactions.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)
Australia (dollar)	19.30	18.12	26.79	50.18	47.11	69.64
Belgium (comm. franc)	973.14	905	1,134	2,530	2,353	2,949
Canada (dollar)	22.73	21.73	28.52	59.10	56.50	74.14
Finland (markka)	101.66	94.34	126.43	264.30	245.26	328.68
France (franc)	147.43	135.24	171.46	383.27	351.60	445.76
FRG (mark)	48.01	43.92	57.22	124.82	114.17	148.77
Italy (lira)	29,697	27,490	34,191	77,206	71,469	88,889
Japan (yen)	4,020	3,805	5,532	10,452	9,892	14,381
Netherlands (guilder)	54.12	49.53	64.35	140.69	128.78	167.30
South Africa (rand)	22.12	21.01	25.34	57.50	54.63	65.88
Spain (peseta)	2,696	2,518	3,185	7,010	6,547	8,280
Sweden (krona)	141.21	130.87	173.90	367.11	340.23	452.09
Switzerland (franc)	39.64	36.37	48.04	103.05	94.56	124.89
UK (pound)	12.66	11.71	14.91	32.90	30.43	38.77
US (dollar)	17.75	17.00	23.25	46.15	44.20	60.44

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)
Australia (dollar)	19.46	20.52	24.65	50.60	53.34	64.10
Belgium (comm. franc)	981.36	1,025	1,044	2,551	2,665	2,714
Canada (dollar)	22.93	24.61	26.25	59.60	63.97	68.24
Finland (markka)	102.52	106.83	116.37	266.53	277.72	302.53
France (franc)	148.67	153.14	157.82	386.51	398.14	410.29
FRG (mark)	48.42	49.73	52.67	125.87	129.28	136.93
Italy (lira)	29,948	31,129	31,471	77,858	80,928	81,816
Japan (yen)	4,054	4,308	5,092	10,540	11,201	13,237
Netherlands (guilder)	54.57	56.09	59.23	141.88	145.82	153.99
South Africa (rand)	22.31	23.79	23.32	57.99	61.86	60.64
Spain (peseta)	2,719	2,851	2,932	7,069	7,413	7,621
Sweden (krona)	142.40	148.19	160.06	370.21	385.26	416.12
Switzerland (franc)	39.97	41.19	44.21	103.92	107.07	114.95
UK (pound)	12.76	13.26	13.73	33.18	34.46	35.69
US (dollar)	17.90	19.25	21.40	46.54	50.05	55.64

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1984.

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CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)	This Month (Apr. 30, 1984)	Last Month (Mar. 31, 1984)	12 Months Ago (Apr. 30, 1983)
Australia (dollar)	0.87	0.85	1.38	1.92	1.88	3.05
Belgium (comm. franc)	43.86	42.60	58.54	96.69	93.91	129.05
Canada (dollar)	1.02	1.02	1.47	2.26	2.25	3.25
Finland (markka)	4.58	4.44	6.53	10.10	9.79	14.39
France (franc)	6.64	6.36	8.85	14.65	14.03	19.51
FRG (mark)	2.16	2.07	2.95	4.77	4.56	6.51
Italy (lira)	1,338	1,294	1,765	2,951	2,852	3,891
Japan (yen)	181.20	179.05	285.51	399.48	394.74	629.44
Netherlands (guilder)	2.44	2.33	3.32	5.38	5.14	7.32
South Africa (rand)	1.00	0.99	1.31	2.20	2.18	2.88
Spain (peseta)	121.53	118.50	164.38	267.92	261.25	362.40
Sweden (krona)	6.36	6.16	8.98	14.03	13.58	19.79
Switzerland (franc)	1.79	1.71	2.48	3.94	3.77	5.47
UK (pound)	0.57	0.55	0.77	1.26	1.21	1.70
US (dollar)	0.80	0.80	1.20	1.76	1.76	2.65

SWU VALUES EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	DOE SWU FY85	Non-DOE SWU delivery within 15 months
Australia (dollar)	114.17	86.98
Belgium (comm. franc)	5,757	4,386
Canada (dollar)	134.48	102.46
Finland (markka)	601.37	458.19
France (franc)	872.09	664.45
FRG (mark)	284.01	216.39
Italy (lira)	75,673	133,846
Japan (yen)	23,783	18,120
Netherlands (guilder)	320.12	243.90
South Africa (rand)	130.84	99.69
Spain (peseta)	15,950	12,153
Sweden (krona)	835.32	636.44
Switzerland (franc)	234.48	178.65
UK (pound)	74.87	57.04
US (dollar)	105.00	80.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1984.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current E.V.	Seller	Buyer	Remarks
2814	1983-92	1,001-1,500	unknown	US Producer	US Utility	Took place late 1983.
2809	1987-96	3,000-5,000	unknown	US Producer	US Utility	Took place late 1983.
2798	1984	101-300	110-125	US Producer	US Producer	Took place late 1983.

Secondary Market Enrichment Services

Nuexco Transaction Number	Delivery Period[2]	Approximate Quantity (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Tails Assay (Percent U_{235})	Seller Group	Buyer Group	SWU Origin	Remarks
2823	1985-6	50-100	110 (see remarks)	0.3	US Utility	US Utility	DOE	Discount from USEC price, so 1986 price is indeterminate.
2804	1984	less than 50	unknown	0.2	US Utility	US Utility	DOE	
2800	1984	50-100	103	0.2	US Entity	US Utility	Eurodif	
2789	1984	50-100	93	0.2	US Utility	US Utility	DOE	

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Refers to calendar year, not fiscal year.
[3] Price is not normalized to 0.20% tails assay.
[4] Refers to SWU Value for same origin as SWUs included in transaction.

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URANIUM SUPPLY
(As of 4/30/84)

CURRENT MARKET DATA

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
1575	—	500 per year	
1818	—	500 per year	
2038	1,000	—	UF_6
2134	220	—	
2201	95	—	
2236	—	200 per year	1985-89
2263	—	500 per year	1985-90
2275	145	—	
2297	—	200 per year	1985-89
2307	880	—	UF_6
2315	450	950	UF_6
2320	330	—	UF_6
2326	—	3,500	1988-91
2335	275	—	
2336	—	250 per year	
2365	20	—	
2368	—	2,800	
2376	340	—	UF_6
2389	300	—	
2390	100	—	
2392	35	—	UF_6
2436 A	850	—	enriched UF_6
2484	130	—	
2505	280	—	U_3O_8 or UF_6
2509	990	1,400	UF_6
2565	400	—	
TOTAL:	7,410		
INACTIVE			
0564	—	1,000 per year	1985-90
2017	1,100	1,200	
2191	125	—	UF_6
2193	—	800 per year	1986-90
2271	—	500 per year	1984-88
2429	450	—	
2473	—	500 per year	1984-90
2483 A	545	—	
2495	130	—	UF_6
2557	860	—	
TOTAL:	3,210		

[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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CURRENT MARKET DATA

URANIUM DEMAND
(As of 4/30/84)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2217	—	1,000 per year	1988-95
2329	—	500	1985
2352	240	—	
2355 A	—	1,400	enriched UF_6
2399 A	—	130	1985
2411	400	—	
2419	80	—	UF_6
2445	—	250 per year	1988-93
2456	650	—	UF_6
2463	260	—	UF_6
2481	100	—	
2492	600	2,000	1984-89
2494	250	250 per year	1984 on
2508	65	—	UF_6
2558	235	—	UF_6
2566	500	—	
TOTAL:	3,380		
INACTIVE			
1999	—	50 per year	1985-90
2244	—	350 per year	
2303	—	275 per year	1985-90
2372	—	250 per year	1985-88
2413	—	250 per year	1986-88
2414	—	150 per year	1987-91
2457	—	650	1987
TOTAL:	—		

[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

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LOAN SUPPLY AND DEMAND
(As of 4/30/84)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
1938	2,000	—	UF_6
2128	1,000	—	
2139	2,000	—	
2483 B	545	—	
TOTAL:	5,545		
Inquiries to Borrow:			
ACTIVE			
2493	250	—	
TOTAL:	250		

[1] Measured from the date of this Report.

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CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(As of 4/30/84)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
ACTIVE			
2051	1,000	—	
2141	2,600	—	
2511	330	330	1986-90
TOTAL:	2,930		
INACTIVE			
1936	1,000	—	
2401	600	—	
2438	220	220	1985-87
TOTAL:	1,820		
Inquiries to Purchase:			
INACTIVE			
2420	300	—	1986
TOTAL:	300		

[1]Measured from the date of this Report.

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SWU SUPPLY
(As of 4/30/84)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale: ACTIVE			
2100	—	100 per year	1986-87
2192	100	210	1986-87
2285	500	3,000	
2345	150	—	
2351	—	250 per year	1986-88
2378	130	250 per year	1987-88
2408	160	—	
2428	80	—	
2436 B	185	—	enriched UF_6
2469	—	80	1987
2510	400	—	
TOTAL:	1,705		

[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

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CURRENT MARKET DATA

SWU DEMAND
(As of 4/30/84)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2237	—	400 per year	1987-90
2346	—	30	1986
2355 B	—	600	enriched UF_6
2400	80	—	
2407	75	130	1986
2412	85	—	
2448	20	—	
2452	30	—	1985
2475	300	300 per year	1988-90
2491	—	80 per year	1987 on
2503	—	330	1986
2552	35	—	
TOTAL:	625		
INACTIVE			
2142	35	—	
2432	50	500	
2440	—	20 per year	1988-91
2449	50	—	
2459	50	50 per year	
2471	60	40 per year	
2512	—	15 per year	1987 on
2567	—	45 per year	1987 on
TOTAL:	245		

[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

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JAPAN

Annual price negotiations between Japanese utilities and some of their important long-term uranium suppliers indicate that the downward price trend of recent years has slowed considerably. During March and April, a group of Japanese utilities agreed to pay $33 to $34 per pound U_3O_8 for 1985 deliveries (fiscal year ending March 31, 1985) from African and European suppliers. While the individual contract prices may be slightly lower than 1984 or slightly higher, the range of $33 to $34 is essentially unchanged since last year.

The *unweighted* average of the agreed prices for 1985 deliveries comes to almost exactly $33.50 per pound U_3O_8. That price level compares to $45 for 1981, $37.75 for 1982, $35.50 for 1983 and $33.70 for 1984. Thus, the agreed prices for 1985 deliveries reflect only minor adjustments based on the individual producers' situations. However, the ratio of these negotiated prices to the prices in the spot and near-term markets (as represented by the Nuexco Exchange Value) has changed substantially since last year. The ratio of the prices agreed for FY84 deliveries (approximately $33.70) to the February 28, 1983 Exchange Value ($21.75) is approximately 1.5:1. The corresponding ratio for FY85 deliveries is approximately 1.9:1, the highest such ratio in the past five years.

To whatever extent spot and near-term prices influence prices under long-term contracts, they almost certainly do not do so on the basis of any single month. It is much more likely that the annual price negotiations are influenced by the developments in spot and near-term prices since the previous year. For example, the price negotiations for FY85 deliveries were much more likely influenced by spot/near-term prices during FY84 (April 1, 1983–March 31, 1984) than by the February 1984 or March 1984 Exchange Values alone. Table 1 shows a comparison for the past five years of annually negotiated prices versus individual Exchange Values and also versus a 12-month average.

Comparing agreed prices to the Exchange Value immediately preceding the onset of negotiations, assuming they take place in March of each year, yields a ratio of 1.2 for FY81 deliveries, 1.5 for FY82, FY83 and FY84, but 1.9 for FY85. That would seem to imply that Japanese utilities are much more willing than before to pay a premium over spot/near-term market prices in exchange for the security of long-term supply. That simply is not the case. A more meaningful comparison is that using the 12-month simple average of Exchange Values for a given fiscal year. For example, the average of Exchange Values for FY84 (April 1, 1983–March 31, 1984) was $22.10; comparing it to the agreed price of approximately $33.50 yields a ratio of 1.5, the same as for FY83 deliveries and less than the 1.7 associated with FY84 deliveries. Those figures are consistent with the idea that, while Japanese utilities want to receive some benefit from the continued depression of spot/near-term prices, they understand the pressures on their suppliers and do not wish to damage healthy long-term relationships for the sake of temporary gains.

Table 1

RESULTS OF ANNUAL JAPANESE URANIUM PRICE NEGOTIATIONS COMPARED TO EXCHANGE VALUE

Fiscal Year Ending March 31	Approximate Agreed Price ($/lb. U_3O_8)	Date of Exchange Value for Comparison	Exchange Value ($/lb. U_3O_8)	Delivery Price/ Exchange Value	Average E.V. for Preceding Japan FY (1980–84) ($/lb. U_3O_8)	Delivery Price/ Average E.V.
1981	45.00	February 29, 1980	38.00	1.2	41.17	1.1
1982	37.75	February 28, 1981	25.00	1.5	28.63	1.3
1983	35.50	February 28, 1982	23.00	1.5	23.65	1.5
1984	33.70	February 28, 1983	21.75	1.5	19.65	1.7
1985	33.50	February 29, 1984	17.50	1.9	22.10	1.5

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RECENT DEVELOPMENTS

SOUTH AFRICA

Beisa

General Mining Union Corporation Limited (Gencor) and St. Helena Gold Mines Limited announced on May 1 their intention to shut down the Beisa mine by the end of this year. In its 1983 annual report, St. Helena had announced that its net loss from uranium had increased from R0.6 million in 1982 to R22.1 million in 1983. The sharply increased losses, coming in spite of improved performance in the mining and metallurgical sections (1,060,000 tons milled in 1983 vs. 611,000 in 1982), were due mainly to a lower than expected recovery grade, as a result of which the mine had to purchase uranium from other concerns at substantially higher prices than in 1982 to meet its contractual obligations.

Under the terms of an agreement between St. Helena and Beisa Mines Limited (Beisa), a subsidiary of Gencor, St. Helena acquired Beisa's mining rights and certain other assets on January 1, 1981. It has been operating the mine since, while Beisa has remained responsible for funding operating losses and capital expenditures.

As announced May 1, St. Helena has decided to discontinue mining and ore treatment operations at Beisa. Arrangements have been made with Nuclear Fuels Corporation of South Africa (Proprietary) Limited, whereby Nufcor has agreed in principle to accept assignment of all obligations under the 1978 uranium supply agreement. Proceeds from the sale of assets, including housing, are expected to cover the major portion of the remaining liabilities relating to the mine.

It is unlikely that the Beisa mine will be able to operate profitably for the foreseeable future. Therefore, the mine will not be placed on a care and maintenance basis but will be completely shut down. Spot uranium prices have fallen to such an extent that negotiated contract prices are little different from those available when Beisa went into production in 1981. At the same time, costs have been increasing at an average rate of about 16 percent per annum. Thus, the cost of production is now 50 percent higher than in 1981, but prices have remained static and even at these low levels are coming under increasing pressure. When Beisa was opened it was hoped that prices would move up, and costs and contracts were entered into on that basis. However, customers have been negotiating lower and lower prices as the uranium market has fallen.

Being a primary uranium producer with gold as the by-product, Beisa has not been able to rely on its gold production to remain profitable. Its demise will reduce South Africa's annual uranium production by approximately 1,000,000 pounds U_3O_8.

First Quarter Production

Uranium production in the Republic of South Africa remained steady during the first quarter of 1983, according to recent figures released by the Chamber of Mines. Total first quarter results of approximately 3,848,000 pounds U_3O_8 from Chamber of Mines producers compares to fourth quarter 1983 production of approximately 3,871,000 pounds (Table 2). Lower production from Chemwes (down 13.9 percent), Buffelsfontein (down 13.4 percent) and JMS (down 15.2 percent) was largely offset by higher production from Blyvooruitzicht (up 22 percent), Vaal Reefs (up 7.3 percent) and Beisa (up 10.9 percent).

Table 2

REPUBLIC OF SOUTH AFRICA:
FIRST QUARTER 1984 URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	Fourth Quarter 1983	First Quarter 1984	Percent Change
Beisa	305	338	+10.9
Blyvooruitzicht	127	155	+22.0
Buffelsfontein	362	313	-13.4
Chemwes (Stilfontein)	360	310	-13.9
Driefontein Consolidated	105	98	- 6.7
ERGO[2]	106	113	+ 6.6
Harmony	310	307	- 1.0
Hartebeestfontein	246	248	+ 0.8
JMS[3]	420	356	-15.2
Randfontein	281	287	+ 2.1
Vaal Reefs	996	1,069	+ 7.3
Western Areas	164	175	+ 6.7
Western Deep Levels	89	79	-11.2
TOTAL	3,871	3,848	- 0.6

[1]Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.
[2]ERGO = East Rand Gold and Uranium Co. Ltd.
[3]JMS = Free State Joint Metallurgical Scheme.

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In reviewing the variations in uranium production from South Africa's gold-uranium by-product operations, it is important to recognize that the mining operation is controlled by gold, not uranium. Thus, South African producers may experience somewhat greater short-term variations than conventional producers elsewhere. Some specific comments regarding first quarter 1984 operations relative to the fourth quarter of 1983 are as follow.

1. **Beisa (St. Helena)**—Average yield (U_3O_8 per ton treated) increased 8.2 percent and tons treated increased 1 percent. 1984 production should total approximately 550,000 pounds U_3O_8.

2. **Blyvooruitzicht**—Average yield increased 18 percent and tons treated increased 3 percent.

3. **Buffelsfontein**—Average yield declined 14.3 percent and 1 percent fewer tons were treated.

4. **Chemwes (Stilfontein)**—Average yield declined 6 percent and tons treated declined 4 percent.

5. **JMS**—Output declined 15.2 percent as the amounts of slimes and flotation concentrates treated decreased by 15.7 percent and 14.4 percent, respectively.

6. **Randfontein**—An 8-percent decline in tons treated largely offset a 14-percent increase in average yield. Randfontein's profit on uranium sales declined almost 50 percent, from R3.7 million to R1.9 million, because of lower contract prices and reduced demand from its only customer. The balance of the company's long-term loan (from its customer) declined to R60.9 million as of March 31, 1984; the company has indicated it will not reduce the loan repayment rate in conjunction with falling demand, but that it intends to continue repaying the loan as though the customer were taking its full quota of uranium deliveries.

7. **Vaal Reefs**—Average yield increased 4.5 percent and tons treated increased 5.2 percent.

8. **Western Areas**—Profit on uranium operations almost doubled, from R1.72 million to R3.37 million. The company expects to maintain production at current levels for most of this year because of high contract deliveries. Uranium sales in 1983 were lower due to portions of 1983 commitments having been delivered in advance in 1982. The balance of their customer loan has been reduced to R27 million, with R640,000 in repayments due within the year.

Palabora

Separately, Palabora Mining Company (PMC) announced sales and shipments totalling approximately 502,000 pounds U_3O_8 during the first quarter of 1984. That total included a shipment of approximately 195,000 pounds, originally scheduled for delivery in 1981, that had been postponed to January 1984 at the request of the customer. First quarter production results for PMC are not available. As reported in Report 188, PMC produced 482,000 pounds U_3O_8 in 1983, which equates to a quarterly production rate of approximately 120,000 pounds.

Other Developments

Some other comments on individual production facilities that have longer-term implications are as follows.

1. **Harmony**—The company announced on March 12 that it had decided to discontinue production at the Merriespruit uranium plant (Report 188, page 18). That plant accounted for approximately 28 percent of Harmony's total uranium production. Thus, this action will reduce South Africa's annual production by about 400,000 pounds U_3O_8.

Production from the Harmony and Virginia uranium plants, together with the existing stock of processor uranium, would be sufficient to meet the company's long-term committed sales. The closure of the Merriespruit plant will result in savings in operating costs and hence, small improvements in profits. The company is investigating the possibility of converting the Merriespruit uranium plant into a gold plant to treat tonnage from the new Harmony No. 4 shaft complex in 1986.

2. **Western Deep Levels**—The proposal to convert a portion of the uranium plant into a gold treatment facility (Report 188, page 18) has been approved by the board of directors of the company. The estimated escalated cost to completion is R35 million and the plan includes the erection of a milling plant and pulp-pumping plant capable of handling 120,000 tons per month. Commissioning is expected to take place by July 1985. The company plans to cease uranium production early in 1985 and will meet existing contracts from stockpiles and other arrangements. When that happens, it will reduce South Africa's annual output by approximately 400,000 pounds U_3O_8. However, the announced production target is approximately 350,000 pounds U_3O_8 from 1,660,000 tons treated at a recovery grade of .209 pounds U_3O_8 per ton.

3. **Randfontein**—Uranium operating profit for the year at R306.1 million was 39.5 percent higher than 1982, and the highest ever recorded. Planned expansion of the Cooke uranium plant to increase its capacity to 300,000 tons treated per month, together with modifications to improve efficiency of this plant, are progressing satisfactorily. Uranium profits over the next twelve months will be adversely affected by a further reduction in the con-

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tractual price as well as by a reduced offtake by the consumer.

4. **Western Areas** – During 1983, the planned tonnage buildup from uranium-bearing Middle Elsburg reef continued and 614,000 tons were treated. The uranium plant continued to operate at a high degree of efficiency on throughput lower than design capacity. Part of the increased tonnage planned to be mined in 1984 will be from Middle Elsburg reefs in order to meet recently negotiated contractual commitmens which require additional uranium oxide production of approximately 130,000 pounds U_3O_8 in each of the next three years.

CORRECTION

Last month's Report (Number 188) contains an error on page 21, in the table entitled "US Nuclear Power Plant Backlog." The fifth line of the table lists WNP Unit 1 where it should list WNP Unit 2. Unit 1 has been indefinitely delayed; Unit 2, however, received a full-power operating license in April 1984.

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NON-US NUCLEAR POWER PLANT BACKLOG

Construction Progress

As of January 1984, 98 units comprised the non-US nuclear power plant backlog (excluding Soviet bloc countries). Table 3 lists those 98 units by country in descending order of construction completion percentage. A unit enters the backlog when construction starts and exits when commercial operation begins. Thus, the backlog does not include units on which construction has not yet begun, such as eleven undergoing licensing in Japan. It also does not include units which have been delayed indefinitely, such as five in Spain.

Table 3 shows the construction completion percentage for each unit as of January 1982, and the change in completion percentage accomplished during the next two years. Table 4 shows a breakdown of the construction progress for all 98 units. The range of progress includes a remarkable 71 percent change in completion percentage achieved by Kansai Electric Power Company of Japan on Takahama Unit 3; it also includes twelve units on which a change of less than 5 percent was made.

Comparison Among Nations

Table 5 presents the current status of active nuclear power programs worldwide. The far-right column of Table 5 shows the average progress on backlog, a megawatt-weighted average of changes in completion percentages, accomplished in each country. A megawatt-weighted average takes account of the varying sizes of units, so that progress on a small unit is given less weight than progress on a large unit. The megawatt-weighted average progress on the entire non-US backlog was 26 percent, 11 percent greater than that for the USA. (See pages 20-21 of Report 188 for an analysis of the US backlog.)

Table 5 also lists the average size of the units under construction in each country, which puts a country's average progress in some perspective. Progress of 25 percent is more impressive when the average size of units under construction is 1100 MWe than when the average size is 600 MWe.

Table 6 ranks the countries that have active construction programs involving six or more units, including the USA, according to construction progress on their backlogs. Japan's average construction progress is by far the best in the world, largely because of the extensive preparation that precedes construction and the absence of delay between construction completion and commencement of commercial operation. (See the article entitled *Nuclear Power Plant Licensing in Japan* on pages 22-25 of Report 188.) France, which has the largest national backlog outside the USA, is progressing on the construction of its backlog almost twice as rapidly as the USA, despite a lack of demand for new capacity in France.

Table 4

CONSTRUCTION PROGRESS ON NON-US BACKLOG BETWEEN JAN. 1982 AND JAN. 1984
(As measured by changes in completion percentages)

Change in Completion Percentage[1]	Number of Units[2]
70-79	1
60-69	3
50-59	3
40-49	18
30-39	15
20-29	18
10-19	22
0-9	16
negative	1
Total	97

[1] As listed in Table 3 of this article.
[2] Excludes one unit in China for which data is not available.

Table 6

INTERNATIONAL RANKING OF NUCLEAR POWER PLANT CONSTRUCTION PROGRAMS

Country	Units Under Construction	Avg. MWe per Unit	Avg. Progress on Backlog[2]
Japan	10	925	48
France	23	1140	28
S. Korea	6	915	25
F.R. Germany	8	1040	23
United Kingdom	9	640	21
USA	46	1110	15
Canada	7	700	10
India	6	220	5

[1] Includes only those countries with 6 or more units currently defined as under construction.
[2] Average progress on backlog measures the average change in completion percentage for units under construction during the two-year period from Jan. 1982 to Jan. 1984, incorporating a MWe-weighted adjustment for differences in the size of those units. The calculation excludes units that began commercial operation during that period.

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Table 3

NON-US NUCLEAR POWER PLANT BACKLOG

Country	Unit	Net MWe	Utility[1]	Completion Percentage		Change in Completion Percentage
				Jan. 1982[2]	Jan. 1984[3]	
Argentina	Atucha 2	692	CNEA	3	25	22
Belgium	Doel 4	1000	Ebes	40	40	0
	Tihange 3	1000	Intercom	30	30	0
Brazil	Angra 1	626	Furnas	100	100	0
	Angra 2	1245	Furnas	10	10	0
	Angra 3	1245	Furnas	1	1	0
Canada	Pickering 6	516	Ontario Hydro	80	100*	20
	Bruce 6	750	Ontario Hydro	70	80	10
	Pickering 7	516	Ontario Hydro	70	80	10
	Bruce 5	750	Ontario Hydro	60	70	10
	Pickering 8	516	Ontario Hydro	60	70	10
	Bruce 7	750	Ontario Hydro	40	50	10
	Bruce 8	750	Ontario Hydro	35	40	5
	Darlington 2	881	Ontario Hydro	5	15	10
China	Quinshan	300	MNE	0	unknown	—
France	Paluel 1	1290	EDF	60	100*	40
	Chinon B2	870	EDF	80	100	20
	Cruas 2	880	EDF	60	98	38
	Cruas 3	880	EDF	50	98	48
	Paluel 2	1290	EDF	50	95	45
	Gravelines C5	910	EDF	40	85	45
	Creys Malville	1200	Nersa	60	85	25
	Cruas 4	880	EDF	40	85	45
	Paluel 3	1290	EDF	40	70	30
	Gravelines C6	910	EDF	30	70	40
	St. Alban 1	1300	EDF	25	70	45
	Flamanville 1	1290	EDF	30	65	35
	St. Alban 2	1300	EDF	40	55	15
	Cattenom 1	1265	EDF	30	55	25
	Paluel 4	1290	EDF	25	55	30
	Flamanville 2	1290	EDF	20	50	30
	Cattenom 2	1265	EDF	15	40	25
	Chinon B3	870	EDF	15	35	20
	Belleville 1	1275	EDF	15	35	20
	Chinon B4	870	EDF	10	25	15
	Nogent sur-Seine 1	1275	EDF	0	25	25
	Belleville 2	1275	EDF	3	21	16
	Nogent sur-Seine 2	1275	EDF	0	12	12
	Cattenom 3	1265	EDF	0	1	1
F.R. Germany	Kruemmel	1260	HEW/ NWK	90	100*	10
	KRB II block B	1244	RWE/ Bayernwerk AG	80	100*	20
	KKP 2	1268	Badenwerk/ EVS	50	95	45
	THTR 300	296	HKG	75	85	10
	Grohnde	1290	Preag	55	85	30
	KRB 2 block C	1244	RWE/ Bayernwerk AG	60	80	20
	Kaerlich	1227	RWE	40	80	40
	Kalkar SNR 300	295	SBK	50	75	25
	Isar 2	1285	KKI	0	20	20
	GKN 2	1230	GKN	0	5	5
India	Mapp 1	220	AEC	99	100	1
	Mapp 2	220	AEC	81	88	7
	Napp 1	220	AEC	57	40	(17)

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Table 3 (continued)

NON-US NUCLEAR POWER PLANT BACKLOG

Country	Unit	Net MWe	Utility[1]	Completion Percentage		Change in Completion Percentage
				Jan. 1982[2]	Jan. 1984[3]	
	Napp 2	220	AEC	18	30	12
	Kapp 1	220	AEC	0	13	13
	Kapp 2	220	AEC	0	13	13
Italy	Cirene	40	Enel	35	56	21
	Montalto 1	982	Enel	13	25	12
	Montalto 2	982	Enel	15	20	5
Japan	Fukushima II-2	1067	Tokyo EPC	66	100*	34
	Onagawa 1	500	Tohoku EPC	32	100	68
	Sendai 1	846	Kyushu EPC	60	100	40
	Takahama 3	830	Kansai EPC	21	92	71
	Fukushima II-3	1067	Tokyo EPC	23	85	62
	Kashiwazaki 1	1067	Tokyo EPC	39	85	46
	Takahama 4	830	Kansai EPC	9	75	66
	Fukushima II-4	1067	Tokyo EPC	13	70	57
	Sendai 2	846	Kyushu EPC	2	50	48
	Tsuruga 2	1115	JAPC	0	36	36
	Hamaoka 3	1066	Chubu EPC	0	15	15
S. Korea	Korea Nuclear 5	895	Kepco	70	90	20
	Korea Nuclear 6	895	Kepco	55	76	21
	Korea Nuclear 7	900	Kepco	17	60	43
	Korea Nuclear 8	900	Kepco	15	50	35
	Korea Nuclear 9	943	Kepco	6	22	16
	Korea Nuclear 10	943	Kepco	6	20	14
Mexico	Laguna Verde 1	654	CFE	67	75	12
	Laguna Verde 2	654	CFE	35	40	5
Philippines	PNPP 1	620	Napocor	23	70	47
South Africa	Koeberg 1	922	Escom	70	100	30
	Koeberg 2	922	Escom	50	96	46
Spain	Asco 2	887	Fecsa Enher	75	98	23
	Cofrentes	930	Hidrola	74	98	24
	Trillo 1	997	UE Endesa	10	44	34
	Vandellos 2	982	Fecsa Enher	10	42	32
Sweden	Forsmark 3	1050	SSPB	20	75	55
	Oskarshamn 3	1050	OKG	30	65	35
Switzerland	Leibstadt	942	KKL	80	100	20
Taiwan	Maanshan 1	907	Taipower	46	94	48
	Maanshan 2	907	Taipower	25	78	53
UK	Heysham A1	625	CEGB	99	100	1
	Hartlepool R1	625	CEGB	99	100	1
	Dungeness B2	600	CEGB	98	100	2
	Hartlepool R2	625	CEGB	97	100	3
	Heysham A2	625	CEGB	87	100	13
	Heysham B1	660	CEGB	2	50	48
	Torness Pt. 1	660	SSEB	5	50	45
	Heysham B2	660	CEGB	1	35	34
	Torness Pt. 2	660	SSEB	2	35	33

*Unit has begun commercial operation during 1984.

[1]See box on page 24 for list of acronyms used in this table.

[2]As listed in *Nuclear News* "World List of Nuclear Power Plants" of December 31, 1981.

[3]As listed in *Nuclear News* "World List" of December 31, 1983, or more recent publications.

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Table 5

ACTIVE NUCLEAR POWER PROGRAMS
(Excluding Soviet Bloc Nations)

Country	Units in Commercial Operation	MWe in Commercial Operation (rounded)	Units Under Construc-tion	MWe Under Construc-tion (rounded)	Avg. Size of Units Under Construc-tion	Avg. Progress on Backlog[1] (MWe-Weighted)
Argentina	2	935	1	690	690	22
Belgium	5	3,450	2	2,000	1000	0
Brazil	0	0	3	3,115	1040	0
Canada	14	7,525	7	4,915	700	10
China	0	0	1	300	300	—
Finland	4	2,210	0	0	—	—
France	36	27,480	23	26,215	1140	28
FRG	13	12,260	8	8,135	1040	23
India	4	800	6	1,320	220	5
Italy	3	1,285	3	2,005	670	9
Japan	25	18,280	10	9,235	925	48
S. Korea	3	1,790	6	5,475	915	25
Mexico	0	0	2	1,310	655	9
Netherlands	2	495	0	0	—	—
Pakistan	1	125	0	0	—	—
Philippines	0	0	1	620	620	47
South Africa	0	0	2	1,845	920	38
Spain	6	3,910	4	3,795	950	29
Sweden	10	7,325	2	2,100	1050	45
Switzerland	4	1,940	1	940	940	20
Taiwan	4	3,110	2	1,815	910	51
UK	31	8,310	9	5,740	640	21
Yugoslavia	1	615	0	0	—	—
TOTAL NON-US	156	101,845	93	81,570	880	26
USA[2]	77	60,300	46	51,170	1110	15
TOTAL	233	162,145	139	132,740	957	22

[1] Average progress on backlog measures the average change in completion percentage for units under construction during the two-year period from Jan. 1982 to Jan. 1984, incorporating an adjustment for differences in the size of those units.
[2] See Report 188 (April 1984) for an analysis of the current US nuclear power plant backlog.

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Table 7

UNITS THAT BEGAN COMMERCIAL OPERATION BETWEEN JAN. 1982 AND JAN. 1984

Country	Unit	Net MWe	Utility[1]	Percent Complete Jan. 1982[2]	COD
Argentina	Embalse 3	600	CNEA	85	Nov 1983
Belgium	Doel 3	900	Ebes	90	Oct 1982
	Tihange 2	900	Intercom	90	Feb 1983
Canada	Pt. Lepreau	640	New Brunswick	96	Jan 1983
	Pickering 5	516	Ontario Hydro	90	May 1983
	Gentilly 1	250	Hydro Quebec	92	Sep 1983
France	Blayais 2	910	EDF	95	Feb 1983
	St. Laurent de Eaux B2	880	EDF	100	Jun 1983
	Cruas 1	880	EDF	70	Aug 1983
	Blayais 4	910	EDF	80	Sep 1983
	St. Laurent de Eaux B1	880	EDF	100	Oct 1983
	Chinon B1	870	EDF	95	Oct 1983
	Blayais 3	910	EDF	95	Nov 1983
FRG	Grafenrheinfeld	1225	Bayernwerk AG	98	Jun 1982
Japan	Ikata 2	538	Shikoku EPC	98	Mar 1982
S. Korea	Korea Nuclear 2	605	Kepco	81	Jul 1983
	Korea Nuclear 3	629	Kepco	93	Apr 1983
Spain	Almaraz 2	930	Hidrola/UE/CSE	95	Nov 1983
	Asco 1	887	Fecsa/Enher	98	Dec 1983
Sweden	Ringhals 4	900	SSPB	100	Oct 1983
Taiwan	Kuosheng 2	951	Taipower	96	Mar 1983
UK	Dungeness B1	600	CEGB	100	Dec 1983

[1]See box on page 24 for list of acronyms used in this table.
[2]As listed in *Nuclear News* "World List of Nuclear Power Plants" of December 31, 1981.

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Growth of Installed Capacity

Between January 1982 and January 1984, 22 units that were part of the non-US backlog in January 1982 began commercial operation. Table 7 lists those 22 units. Since January 1984, five units listed in Table 3 have begun commercial operation; those five, one each in Canada, France and Japan, and two in Germany, are denoted by an asterisk next to the completion percentage in Table 3. Withdrawing those five units leaves 93 units comprising the actual current non-US backlog.

Of the 93 units in the current backlog, a number are near the commercial stage. In fact, twelve units other than the five that recently began commercial operation are listed in Table 3 as 100-percent complete, which in most cases means they have begun some degree of operation. For example, Escom's Koeberg Unit 1 (South Africa) has been connected to the grid, and Furnas' Angra Unit 1 (Brazil) operated at 100-percent capacity recently. Table 8 lists the number of units in the current non-US backlog that are within each ten-percent range of completion percentage. Nearly 25 percent of the non-US backlog is between 90 and 100-percent complete. Fifty percent of the backlog is 70-percent complete or more. This data suggests that non-US nuclear electricity generating capacity, like that of the USA, will increase considerably within the next two to three years.

Table 8

COMPLETION PERCENTAGES OF UNITS IN NON-US BACKLOG

Percent Complete[1]	Number of Units[2]
90 100	21
80 89	12
70 79	13
60 69	3
50 59	10
40 49	7
30 39	8
20 29	9
10 19	6
0 9	3
Total	92

[1] As listed in Table 3 of this article.
[2] Excludes four units listed in Table 3 that have begun commercial operation during 1984, and one unit in China for which data is not available.

Acronyms Used in Tables 3 and 7

AEC = Atomic Energy Commission (India)
CEGB = Central Electricity Generating Board
CFE = Comision Federal de Electricidad
CNEA = Comision Nacional de Energia Atomica
CSE = Compania Sevillana de Electricidad S.A.
Ebes = Societes Reunies d'Energie du Bassin
EDF = Electricite de France
Endesa = Empresa Nacional de Electrica S.A.
Enel = Ente Nazionale per l'Energia Electrica
Enher = Empresa Nacional Hidroelectrica Ribagorzana
EPC = Electric Power Company
Escom = Electricity Supply Commission
EVS = Energie Versorgung Schwaben
Fecsa = Fuerzas Electricas de Cataluna S.A.
GKN = Gemeinschaftkernkraftwerk Neckar
HEW = Hamburgische Elektrizitatswerke
Hidrola = Hidroelectrica Española S.A.
HKG = Hochtemperatur-Kernkraftwerk GmbH
Intercom = Societe Intercommunale Belge de Gaz et d'Electricite
JAPC = Japan Atomic Power Company
Kepco = Korea Electric Power Corporation
KKI = Kernkraftwerk Isar
KKL = Kernkraftwerk Leibstadt AG
MNE = Ministry of Nuclear Energy (China)
Napocor = Philippine National Power Corporation
Nersa = Centrale Nucleaire Europeene a Neutrons Rapides S.A.
NWK = Nordwestdeutsche Kraftwerk
OKG = Oskarshamnsverkets Kraftgrupp Aktiebolag
Preag = Preussische Elekrizitats AG
RWE = Rheinisch-Westfalisches Elektrizitatswerk
SBK = Schneli-Bruter-Kernkraftwerksgesellschaft
SSEB = South of Scotland Electricity Board
SSPB = Swedish State Power Board
Taipower = Taiwan Power Company
UE = Union Electrica

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THE DEENRICHMENT SWAP

Introduction

A common form of transaction in the secondary market for enrichment services is the *deenrichment swap*. Through a deenrichment swap, an owner of enriched UF_6 (enriched product), or of a future commitment to take enriched product from a primary SWU supplier, gives title of that product to a buyer. In exchange, the buyer gives the seller an amount of natural UF_6 (usually an amount equivalent to that used to produce the enriched product), plus cash for the enrichment services.

Deenrichment swaps enable holders of unwanted inventories of enriched UF_6, or unwanted SWU commitments to a primary supplier, to dispose of them, usually in exchange for cash. The incentive for a buyer having natural UF_6 is the opportunity to purchase needed SWUs at a price below the primary market price.

Transaction Mechanism

The terms and conditions of a deenrichment swap transaction are established in a contract signed by the SWU seller and the SWU buyer. Such a contract ordinarily will contain the following information:

1. The quantity of enriched product to be transferred to the buyer, either directly by the seller or by the primary enricher at the instruction of the seller.
2. The product assay level of the enriched UF_6.
3. The tails assay at which the enriched product was, will be, or will be deemed to have been, enriched by the primary SWU supplier.
4. The number of SWUs required to produce the enriched UF_6, given the tails and product assay specifications.
5. The price to be paid by the buyer to the seller.
6. The amount of natural UF_6 to be transferred by the buyer to the seller (usually equivalent to the amount used to generate the enriched product according to the tails and product assay specifications of the contract).
7. The schedules for delivery of feed material (usually natural UF_6), enriched product, and cash.

In the case of a seller having an inventory of enriched product, that product may or may not be enriched to the assay level desired by the buyer. If the product in inventory has been enriched to an assay level less than the assay level desired by the buyer, it may be enriched further (upgraded) by a primary SWU supplier, either at the direction of the seller as part of the transaction, or at the direction of the buyer at a later date. Similarly, the actual tails assay at which the enriched inventory was produced may be different from that which the buyer would like to use in the transaction. The tails assay may be adjusted to suit the feed-to-product and SWU-to-product ratios necessary to conclude a transaction. (See the examples in Figures 1, 2 and 3.)

Alternately, in the case of a seller having a commitment to take future enrichment services from a primary SWU supplier, the seller must notify the primary supplier of the enrichment specifications a certain period of time in advance of delivery. (In most cases, this "advance notice period" has been 180 days for services provided by DOE.) The seller can dictate to the primary supplier the buyer's specifications for enriched product assay and quantity of enriched product, as contained in the contract signed between buyer and seller. In addition, holders of certain types of enrichment contracts may vary the tails assay within a specified range.

Ordinarily, delivery of enriched product in a deenrichment swap is accomplished by a simple book transfer from the seller's account to the buyer's account with the primary SWU supplier. In some cases, the product may be delivered directly to the buyer or to a fabricator. Normally, at the time of product delivery the buyer makes a cash payment to the seller for the SWUs involved. The buyer also delivers to a specified location, either actually or by book transfer, the quantity of natural UF_6 feed defined in the agreement.

Hypothetical Transaction

Suppose that Utility A needs 10,000 kgU of UF_6 enriched to 3.0 weight-percent U^{235} for a future reload. Using a tails assay of 0.3 weight-percent (w/o), Utility A's fuel manager calculates that 34,240 SWUs and 65,690 kgU of natural UF_6 feed are needed to generate the desired product. Utility A has a large inventory of natural UF_6, but does not have coverage for enrichment services. Thus, Utility A is in a position to purchase the necessary enrichment services in the open market.

A second utility, Utility B, has a contract with a primary supplier of enrichment services that requires Utility B to take 35,000 SWUs in excess of its current requirements, at a price of $150 per SWU, or to pay contract termination fees of $70 per SWU. Thus, Utility B is in a position to sell up to 35,000 SWUs scheduled for delivery within the year.

Nuexco matches Utility A's requirement with Utility B's excess commitment, and a transaction between the utilities is arranged at a price of $100 per SWU. At a pri-

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mary market price of $150, the $100 price would provide a savings of $50 per SWU to Utility A. Utility B would take a net loss per SWU of $50, but that compares favorably with the cost of carrying unwanted enriched inventory for five years or more, or with the cost of termination.

Utility B informs the primary SWU supplier of the quantity of enriched product (10,000 kgU), the enrichment assay (3.0 w/o), the tails assay (0.3 w/o), and the desired delivery date, in accordance with the primary enricher's advance notice period. Utility B also delivers 65,690 kgU of natural UF_6 to the primary enricher in accordance with the normal feed delivery schedule.

On the date of product delivery, Utility B transfers to Utility A's account with the primary enricher the 10,000 kgU of enriched product. Utility A wires a cash sum of $3,424,000 to Utility B, and transfers 65,690 kgU of natural UF_6 to Utility B's account at a conversion or enrichment facility. Within thirty days after delivery of the enriched product, Utility B pays $5,136,000 to the primary enricher. This hypothetical transaction is illustrated in Figure 1.

Variation of Tails Assay

If Utility A evaluated the transaction on the basis of a lower tails assay, the number of SWUs involved in the transaction would increase, while the necessary amount of feed would decrease. For any tails assay in the range allowed by the primary enricher, there is a unique combination of feed and SWU quantities that will produce the same quantity of enriched product. Thus, for example, if the transaction had been based on a tails assay of 0.2 w/o rather than 0.3 w/o, 43,060 SWUs and 54,790 kgU of natural UF_6 feed would have been necessary to generate the same 10,000 kgU enriched to 3.0 w/o U_{235}. The effect on the transaction of this variation in tails assay is illustrated in Figure 2.

A more complicated variation of tails assay is illustrated in Figure 3. In this case, the contract with the primary SWU supplier is based on a 0.3 w/o tails assay, and the agreement between Utility A and Utility B is based on a 0.2 w/o tails assay. Note that Utility B's net cash loss is relatively smaller, but is compensated for by a net loss of feed. The situation could be reversed if Utility A requested a 0.3 w/o tails assay and Utility B was obliged to take a 0.2 w/o tails assay from the primary supplier. In that case, Utility B's net cash loss would be relatively greater, but would be compensated for by a net gain of feed.

Figure 1

HYPOTHETICAL DEENRICHMENT SWAP
(Using tails assay of 0.3 w/o)

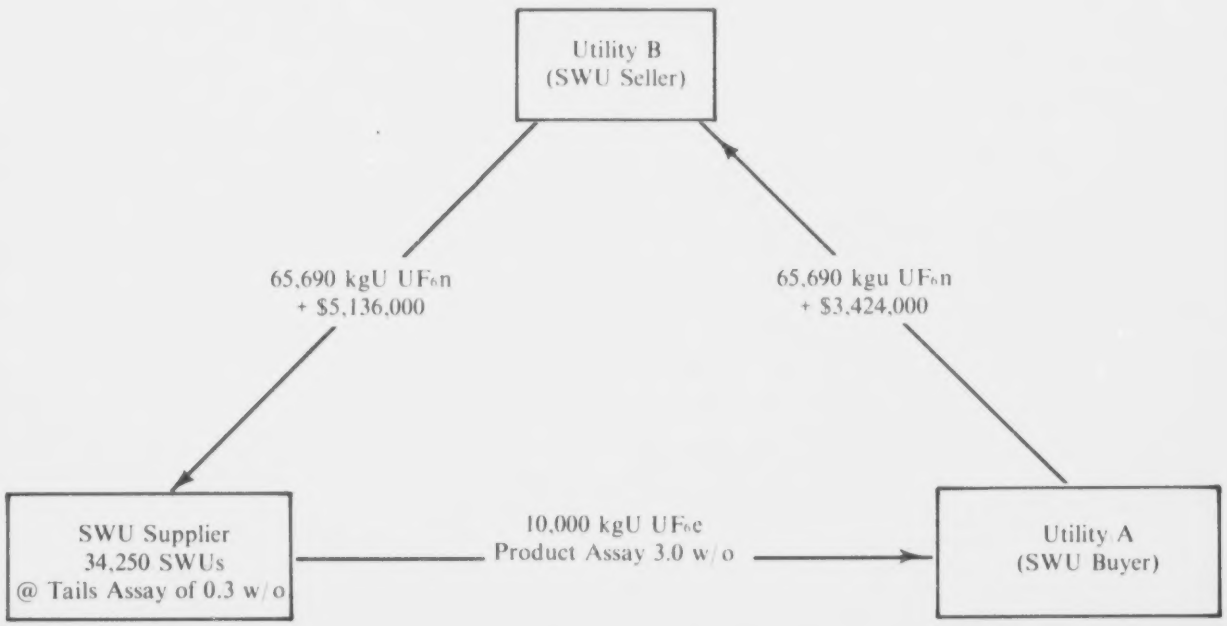

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Figure 2

HYPOTHETICAL DEENRICHMENT SWAP
(Using tails assay of 0.2 w/o)

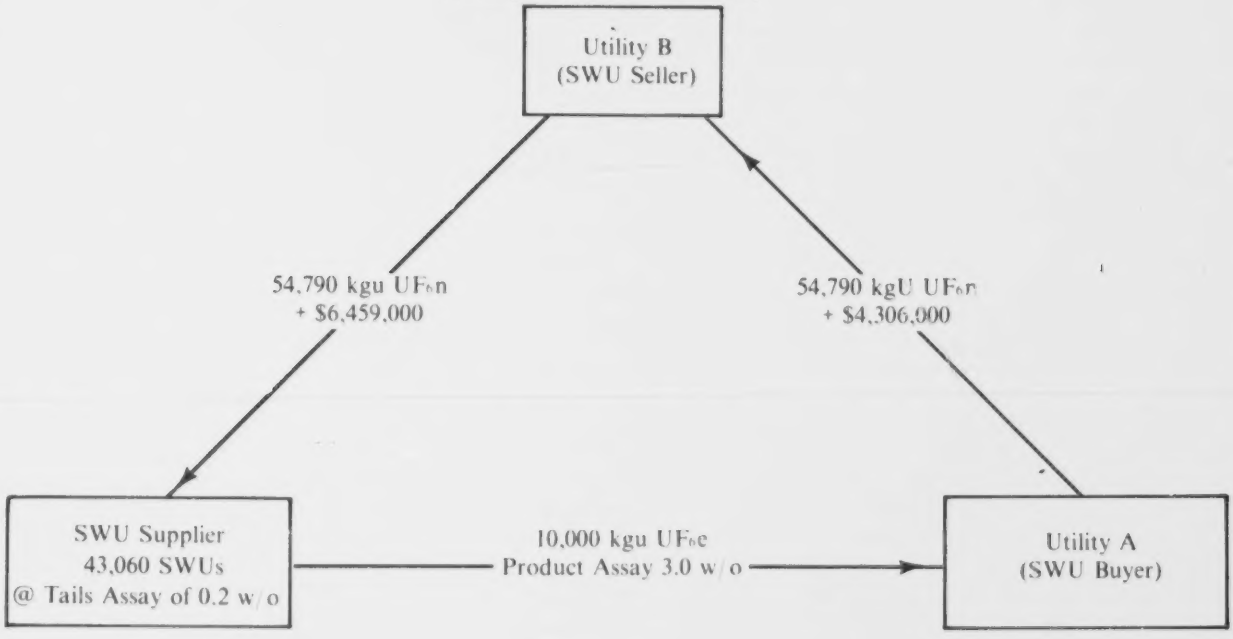
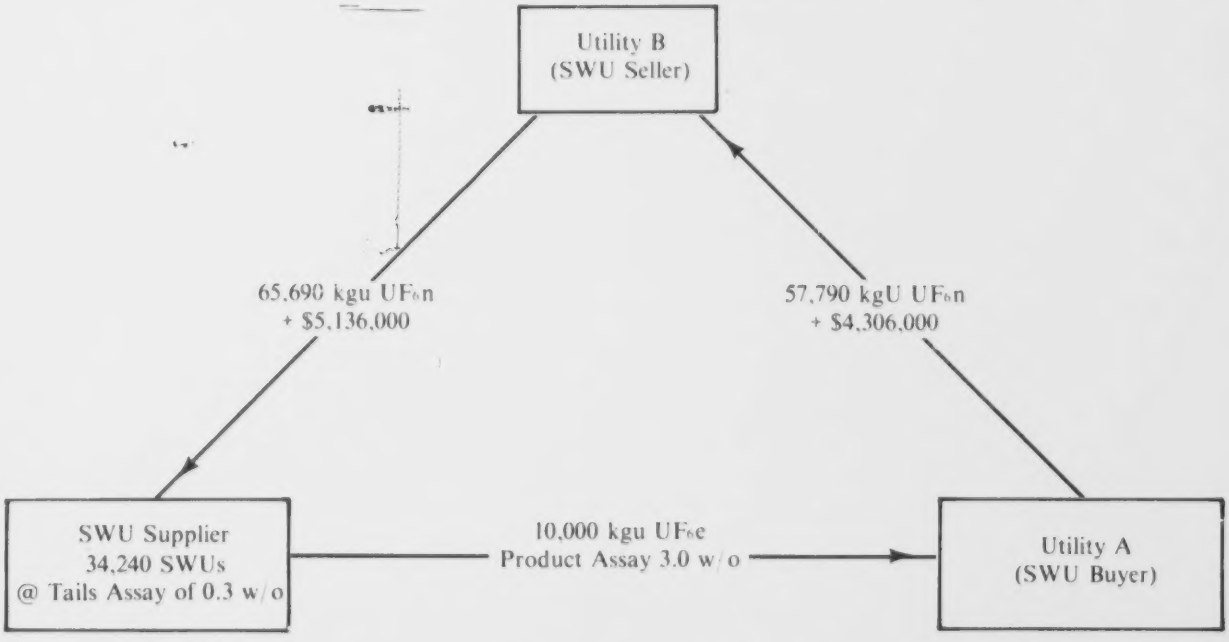


Figure 3

HYPOTHETICAL DEENRICHMENT SWAP
(Using combined tails assays of 0.2 and 0.3 w/o)



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Other Transaction Types

Other than the deenrichment swap, the most common types of secondary market SWU transaction are the contract assignment and the enriched product sale. In an *enriched product sale*, an owner of enriched product sells the entire commodity to a buyer for cash or other considerations. The price paid by the buyer reflects both the natural uranium and the SWU components of the product. An enriched product sale may be attractive to a holder of a large unwanted inventory of enriched UF_6, if that holder is not interested in retaining the natural uranium component of the product. Such a transaction may be attractive to a buyer if the buyer lacks both natural uranium and enrichment services, and has the financing to pay for the entire product at once.

In a *contract assignment*, a seller that has an unwanted contract obligation to take enrichment services from a primary SWU supplier pays a buyer to assume all or part of that contract obligation. Commonly, the amount of the payment by the seller is expressed as a discount off the primary SWU price. Thus, if Utility C assigns 10,000 SWUs to Utility D at a discount of $10, Utility C will pay Utility D $100,000, and Utility D will assume the obligation to pay the primary SWU supplier.

Payment from the assignor (Utility C) to the assignee (Utility D) can be made in any of several ways, each of which has essentially the same effect.

1. In the preferred method, the assignor transfers to the assignee all or part of the prepayment credits paid earlier to the primary SWU supplier. This method's use of funds already paid to the primary supplier is free of risk to the assignee, but more importantly, it allows the assignor to use funds already expended, rather than using new funds.

2. In other methods, the assignor pays the funds directly to the assignee. The payment may take place on delivery of the SWUs, in which case the assignee takes the risk that the assignor might not be able to pay at the appointed time.

3. When the assignor pays the discount to the assignee upon signing the contract for SWU assignment, the discount may be adjusted downward to reflect the time value of money associated with the time interval between contract signing (payment date) and the date the assignee withdraws the SWUs from the primary enricher.

Generally, a contract assignment may be made only with the consent of the primary enrichment supplier. That feature is the most important way in which assignments differ from sales and swaps. Assignments differ from sales and swaps in two other related ways.

1. A deenrichment swap caters to the hard cash needs of a seller, while an assignment caters to the cash needs of a buyer. The financially weaker party is normally the price leader in the transaction.

2. A deenrichment swap involves relatively more work by the seller, while an assignment involves relatively more work for the buyer. "Relatively more work" includes, at the very least, the responsibility for doing business with the primary enricher. That responsibility may be considered undesirable, particularly if the primary enricher seeks to hinder activity in the secondary SWU market.

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URANIUM ENRICHMENT IN JAPAN

Introduction

Japan has come to rely heavily on offshore suppliers for enrichment services: 24 LWRs requiring enriched uranium are now in commercial operation; 23 more are in the planning, licensing or construction stages. For more than a decade the government has promoted a domestic enrichment program with the goal of providing Japan some degree of fuel self-sufficiency. Government-sponsored Power Reactor and Nuclear Fuel Development Corporation (PNC) has demonstrated the technology required for commercial-scale centrifuge facilities. Recently a preliminary site for a commercial plant was defined, and the government has urged the utilities to coordinate development plans. However, because of the large and economical supply of enrichment services in the world market, the utilities may hesitate to commit resources to a commercial plant for several years.

Figure 4

LOCATION OF ENRICHMENT FACILITIES IN JAPAN

PNC Centrifuge Program

In the late 1950s, a government-sponsored company known as Atomic Fuel Corporation began research on uranium enrichment processes. In 1964 the company fabricated and tested Japan's first enrichment centrifuge machine. In 1967 the government (with some support from private industry) established PNC to undertake research and development on advanced reactors and fuel technologies. PNC absorbed the staff and programs of Atomic Fuel Corporation at that time. In 1972, following a three-year evaluation of alternate enrichment technologies, Japan's Atomic Energy Commission (AEC) directed PNC to commence a major research and development effort on centrifuge enrichment.

By 1974 PNC successfully fabricated and installed at its Tokai works, north of Tokyo, an initial cascade having 180 centrifuge machines. A second, 250-machine cascade was completed in 1975. Those two cascades tested SWU output and machine performance under both normal and abnormal operating conditions.

Pilot Plant

In 1976 the AEC authorized PNC to build a pilot plant at PNC's Ningyo-Toge Works in western Japan (Figure 4). Construction on the first phase of the pilot plant, designated OP-1, began in 1977. Approximately 1000 machines (referred to as OP-1A machines) were completed in September 1979, while approximately 3000 more (OP-1B machines) were completed in October of that year. The 4000 OP-1 machines achieved full operation in October

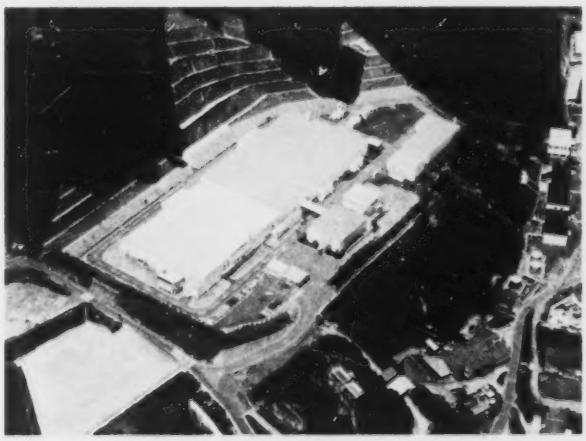

Figure 5. Aerial view of uranium enrichment pilot plant, Ningyo-Toge.

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1980. PNC made the first enriched UF_6 shipment from the Ningyo-Toge pilot plant in April 1981.

Construction on the second phase of the pilot plant (designated OP-2) was completed in October 1981. Continuing research and development at PNC's Tokai facility enabled PNC to incorporate into the 3000 OP-2 machines improvements to the OP-1 machine designs. The OP-2 machines achieve approximately twice the separative work output of the OP-1 machines. Also, the hardware configuration of the OP-2 machines permits a work output per unit area that is five times greater than that of the OP-1A hardware arrangement.

PNC achieved full operation of the approximately 7000 machines at the Ningyo-Toge pilot plant in March 1982. The plant produces at a rate of approximately 50,000 SWUs per year. Since December 1982, the enriched product has been used to fuel PNC's Fugen unit, a 165-MWe heavy water-moderated, light water-cooled demonstration reactor. The pilot plant's performance has exceeded PNC's most optimistic expectations. The annual machine failure rate has been below 0.2 percent, compared to a targeted rate of 1.0 percent. Figure 5 is an aerial view of the pilot plant; Figure 6 shows the control room.

Demonstration Plant

In addition to operating the 7000-machine pilot plant, PNC is continuing centrifuge and cascade development at the Tokai Works. In March 1983 the company successfully re-enriched depleted uranium recovered from its demonstration reprocessing plant at Tokai. PNC has developed centrifuge machines that have three times the SWU output of the pilot plant's OP-1A machines. A cascade of new machines will be tested for reliability later this year.

Figure 6. Central control room of pilot plant.

PNC has begun groundwork at the Ningyo-Toge Works on a demonstration enrichment plant that will have the capacity to produce 200,000 SWUs per year. The first increment of capacity (100,000 SWUs per year) is scheduled to begin operation in 1987, and full capacity operation is scheduled for 1988.

Plan for Commercial Plant

At the recommendation of the AEC, the government has urged the utilities and the associated industrial groups to take the following steps for construction of a commercial-scale enrichment plant.

1. The private utilities should finance a company to construct a facility having the capacity to produce 1 million SWUs per year by 1995. The plant should be expanded to a capacity of 3 million SWUs annually by the year 2000, and should use the technology developed by PNC.

2. The three electrical hardware makers (Toshiba, Mitsubishi Heavy Industries, and Hitachi) should organize a joint venture manufacturing company to produce the necessary machinery for the plant. (On the order of 100,000 centrifuge machines would be required for the facility.) The three hardware makers are the primary suppliers of LWRs to the utilities, and have been the primary hardware suppliers to PNC.

Realization of an enrichment plant in the time frame promoted by the government may depend on a greater degree of state participation than the government currently proposes. Thus far, the government (via PNC) has borne the primary share of the costs for the domestic enrichment program. There is little economic motivation for the utilities to make the capital expenditures necessary for a commercial plant at the present time. Inventories of enriched uranium and the supply of enrichment services worldwide greatly exceed demand; that supply is likely to remain adequate well into the next century. The arguments in favor of the government's plan, however, are in keeping with Japan's traditional conservatism regarding security of fuel supply.

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THE ROSSING PROJECT (PART 2)

Ore Body Development

Rio Tinto Management Services South Africa (Pty) Ltd. began to develop a mine plan for the Rossing uranium deposit in 1970. The initial plan was to establish a mine and mill operation having an annual capacity of 2500 tonnes U_3O_8. Rio Tinto contracted engineering and design work for a processing plant to Davy Power Gas (UK) and Western Knapp (USA) in 1971. A project feasibility study was completed by May, 1973; the decision to go ahead with the project was announced three months later.

Simultaneous with the decision-making period, uranium market opportunities began an upward trend worldwide. RTZ negotiated additional sales contracts and made the decision to increase production capacity to 5000 tonnes U_3O_8 annually. Mine and mill development plans were altered to meet that schedule. Construction began in July 1974; the first natural uranium concentrates were produced in June 1976.

The analytical results of surface drilling and underground work served as a basis for an ore reserve estimate at Rossing. Three-dimensional ore blocks were established using compatible computer technology. The minable dimension per ore block was estimated for contained tons and grade, with comparative relationship to adjacent blocks.

The three-dimensional ore blocks were factored into a mine development schedule. A computerized series of mine-life programs indicated that open pit mining over a minimum period of 20 years was the optimum operating schedule for the project. The long-term mine plan established a format for general pit development, structured to accommodate the mining process on 15-meter-high benches (working levels in the pit) with an average pit wall slope of 45 degrees.

Figure 7 illustrates the bench and mining pattern. At the end of the 20-year period, the pit will measure approximately 3 km long, at least 1 km wide, and 300m in depth (22 benches). Production of uranium is tentatively scheduled to terminate at that time; however, ore reserves are sufficient to support the program beyond 20 years.

Mine Operations

To carry out the large-scale mining operation (40,000 tonnes ore and 100,000 tonnes of waste per day), medium and short-term mine plans were coordinated into the 20-year plan. The mine now operates under the following master plan to maintain a favorable mining schedule:

1. A five-year plan guides long-range pit development, and is updated annually.
2. A one-year plan establishes the mining sequence over each 90-day period, and is updated quarterly.
3. A three-month plan, updated monthly, determines the mining sequence and average ore grade going to the mill for a 30-day period.
4. A monthly plan is updated on a weekly schedule.
5. Production is reviewed daily and projected ahead on a weekly schedule.

The mining schedule has not been maintained without related problems. One condition that is particularly troublesome is the erratic distribution of mineralization throughout the deposit. The high level of production at a satisfactory grade requires continuous drilling on a selected grid of 20m × 20m. The holes are drilled to a depth of 45m, allowing for a progressive estimate of reserves and production for the next three mine levels. The short-term mining sequence is further evaluated from the radiometric results of blast holes, which are usually drilled to a depth of 5m on a grid of 8m × 8m.

Grade control begins with the radiometric logging of each drill hole, followed by analysis of drill cuttings. The ore and waste zones are plotted accordingly, and the mine schedule is established on a medium or short-term schedule. Blasted rock is divided into four grade categories before removal from the pit begins. A grade control engineer enters the pit immediately after the blast to determine radiometrically the grade of the broken rock. A color code is used to designate high-grade ore, medium-grade ore, low-grade ore, and waste rock.

Specialized blasting techniques are applied to minimize mixing of ore-types and dilution of the ore, which is a serious potential problem. Effective grade control is practiced also by radiometric scanning of each truckload of material coming from the mine. High and low-grade ore mined together is trucked directly to the primary crusher; in the absence of high-grade ore, only medium-grade is crushed and the low-grade is stockpiled for later mixing with high-grade. Mill head grades are controlled at about 0.035 percent U_3O_8 by this procedure.

Ore Processing

The metallurgical plant at Rossing is the largest uranium processing facility in the world. It was designed to operate at 40-45,000 tonnes ore per day. Although the plant began operating in mid-1976, design capacity was not attained until early 1979 due to a number of start-up

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problems, some of which required modifications to plant design. The most serious problem was related to the abrasive nature of the uranium-bearing alaskite. The rock contains over 30 percent quartz, which causes excessive wear on machinery, primarily the crushing units and certain conveyor and piping systems. The plant experienced considerable down-time in the early months of operation as a result. A special group of engineers was assigned the urgent task of solving that problem and of improving the milling process in general. The ultimate task of the group was to improve uranium recovery, which was consistently below 80 percent at that time.

A number of design changes were implemented starting with an improved crushing process. The task was essentially accomplished by the first quarter of 1979. Daily mill run increased to 40,000 tonnes and U_3O_8 recovery improved to 85 percent. The operation has continued near those levels since.

The Rossing recovery plant utilizes an acid leach, ion exchange, and solvent extraction process. The ore is trucked from the mine directly to the primary crushing unit. The crushed material exits the unit as coarse ore at a minus 160mm (about six inches). The ore passes on to a stockpile which is maintained at 70–80,000 tonnes, a two-day ore supply to the mill. The ore is next delivered to the secondary crushing unit where it is reduced to a minus 65mm. The ore is then screened to a minus 19mm. The material falling through the screen goes directly to the fine-ore storage area. The oversized material passes through yet another crushing stage, then back to the screen, and on to fine-ore storage. The screens were added to the crushing circuit to minimize the abrasion problem downstream. The capacity of the crushing plant is 2500 tonnes per hour.

The fine ore is further reduced to a minus 1.7mm in four rod mills, each with an hourly capacity of 500 tonnes. As the ore enters the rod mill, water is added to maintain a pulp density of 76 percent solids. The water is preheated to 45 degrees C to enhance leaching conditions. The main uranium mineral present is uraninite, which occurs as grains up to 0.3mm in size. It is liberated during the grinding phase and is readily exposed to the leach lixiviant in the next milling phase. The fine ore enters by conveyor belt, and exits as slurry through overhead piping systems. Figure 8 is a view of the rod mill.

The heated pulp from the rod mills is fed directly to the acid leach circuit, which includes two parallel lines of six tanks each. The tanks are mechanically agitated, affording total particle contact with the acid lixiviant at all times. Manganese dioxide is added before the pulp enters the leach circuit to facilitate oxidization of the uranium. Sulfuric acid is added to the first and second tanks where leaching is initiated at 50 degrees C. Retention time for the leach circuit is 13 hours. About 85 percent of the contained uranium is taken into solution.

The product leaving the leach circuit contains a uranium-rich slime and suspended sand particles. The material is directed through hydrocyclones, where separation takes place. The overflow contains the slime and is sent directly to the countercurrent decantation circuit. The sand underflow is washed to remove the last traces of uranium and sent directly to the tailings disposal area.

Uranium is washed from the slime as it passes through the five decantation thickeners. The uranium-bearing solution flows from the fifth thickener to the ion exchange section. Any sand recovered from the thickeners is sent to the tailings disposal area.

The pregnant solution is pumped to the continuous ion exchange circuit, consisting of the Porter up-flow fluid bed ion exchange contractors. The upward flow of pregnant solution fluidizes the resin bed. The resin is loaded with uranium as it moves counter to the fluids. The loaded resin is transferred to a fixed-bed column system for elution with a solution containing 10 percent sulfuric acid.

The acidic eluate produced is transferred to the solvent extraction plant, where it is mixed with an organic solvent that takes up the uranium. The loaded organic solution is then mixed with an ammonium sulfate solution that absorbs the uranium, producing what is termed "OK liquor" to be sent to the recovery plant for final processing.

Additional ammonia is added to the OK liquor in the precipitation plant, and the uranium precipitates out as ammonium diuranate. The product is recovered on rotating drum filters as a yellow paste. It is then roasted to drive off the ammonia, producing a final product of uranium oxide or yellowcake, which is packed in steel drums for shipment.

Mineralogy

Uraninite is the most important primary uranium mineral present in the Rossing deposit. It makes up about 55 percent of total uranium contained in the rock. Betafite also is a primary mineral, occurring as 5 percent of contained uranium. However, it is a refractory mineral, essentially all of which is lost to recovery because it cannot be liberated by the acid leach process.

Secondary uranium minerals make up the remaining 40 percent. The main mineral is beta-uranophane, followed by metatorbernite and carnotite. The secondary minerals

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Figure 7. Bench configuration and sequential stripping and mining pattern from upper to lower benches.

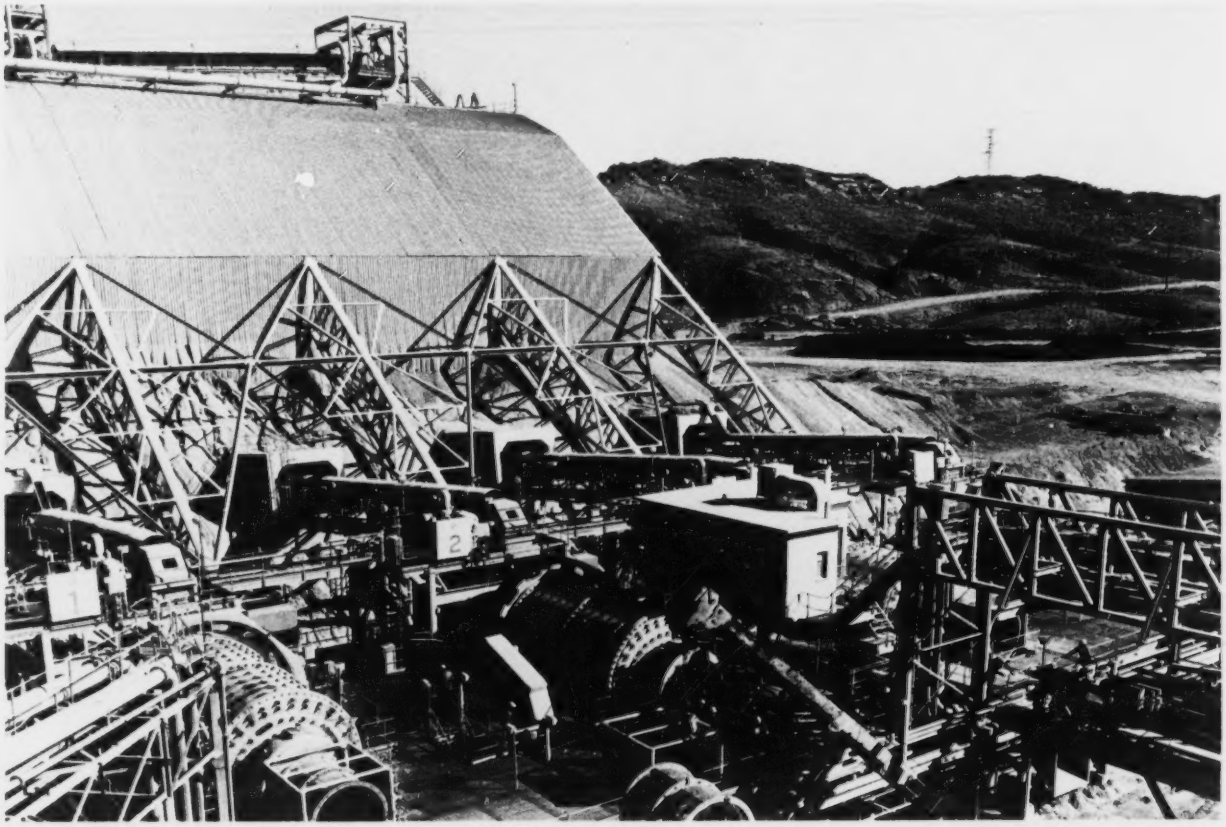

Figure 8. View of the rod mill circuit. Ore enters the rod mills from the fine-ore storage area by conveyor; it exits as a pulp to the acid leach circuit.

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usually occur as bright yellow or green minerals associated with alteration zones in the host rock.

The primary mineralization occurs in close association with concentrations of quartz, feldspar and biotite in the alaskite. In fact, the ore minerals show an affinity to biotite-rich structural features (fault and fracture zones). The secondary minerals naturally parallel the same pattern. Migration into normally barren country rock is a common occurrence, but rarely in minable quantities.

The mineralization shows zoning in the alaskite. It occurs in two different stratigraphic horizons referred to as the north ore zone and the central ore zone. The zones tend to diverge on the western side of the deposit, separated by a large block of barren hornblende gneiss. The two zones are exposed on the surface near the western end of the deposit. To the east, the zones converge and thin, assuming an almost vertical dip. The determined outline of mineralization measures approximately 3 km long and 1 km wide. Structurally, the ore deposit pitches to the southeast, becoming too deep for mining under the existing mine plan.

The origin of uranium minerals at Rossing is probably related to the implacement of the granites in the area. The primary minerals were included as an integral part of the rock-forming process. The obvious high-grade concentrations forming ore zones probably developed as a result of segregation or banding that occurred in the early stages of consolidation (cooling) of the igneous rocks. The secondary minerals may be hypogene, a product of alteration and enrichment created by ascending solutions.

Geology

The Rossing uranium deposit occurs in rocks identified with the Damaran Orogeny, the geologic age estimated between 600 and 500 million years ago. The Damaran orogenic belt extends for several hundred miles in a northeast-southwest direction through Namibia, covering most of the Namib Desert region, northward into southern Angola, and possibly as far east as Zambia.

The Damaran series is late Precambrian in age, consisting of folded and metamorphosed rocks in close association with structurally related synclines and anticlines that parallel the belt trend. Domal structures interrupt the syncline/anticline sequence, suggesting a later period of orogenic activity along the Damaran belt. Extensive intrusions of granite and pegmatite disrupt the structural pattern throughout the belt, especially in the central area around Rossing Mountain. It is within this zone of geologic environment — granitic intrusions and intense metamorphism — that the Rossing uranium deposit occurs.

The uranium-bearing alaskite granites at Rossing have intruded a highly metamorphosed section of the Khan and Rossing formations. The Khan represents the upper portion of the Nosib Formation, which is in unconformable contact with Abbabis metasediments of early Precambrian age. The Khan sequence is dominated by hornblende gneiss and biotite schist up to 250 meters thick. The Khan is broken by intrusive bodies and dikes of uraniferous alaskite, making it an important stratigraphic sequence to mining.

The Rossing Formation directly overlies the Khan Formation. It has been divided into six members, or units, of which about 120 meters of the lower four units have been influenced by intrusions of uraniferous alaskite. Transgressing upward, the basal unit consists of marble containing little mineralization. The overlying unit consists of biotite gneiss that is highly displaced by alaskite; it is one of the main mineralized units. The next unit is conglomeratic, grading from 5cm-sized quartz pebbles in the southern part of the ore deposit to coarse arkosic sand in the eastern part. Banded marble, quartzite and biotite schist make up the upper stratigraphic unit containing important uranium mineralization. The ore deposit is situated within this stratigraphic environment on the limb of a large domal/synclinal structure.

Locally, the intensity of structural events is exemplified by tightly folded and distorted rock, especially within the Rossing Formation. Faulting is common on the peripheral limits of the domal structure, with vertical and horizontal displacement up to about 50 meters. Fracturing is common in all rock types; in the alaskite, it provides a favorable environment for secondary uranium mineralization.

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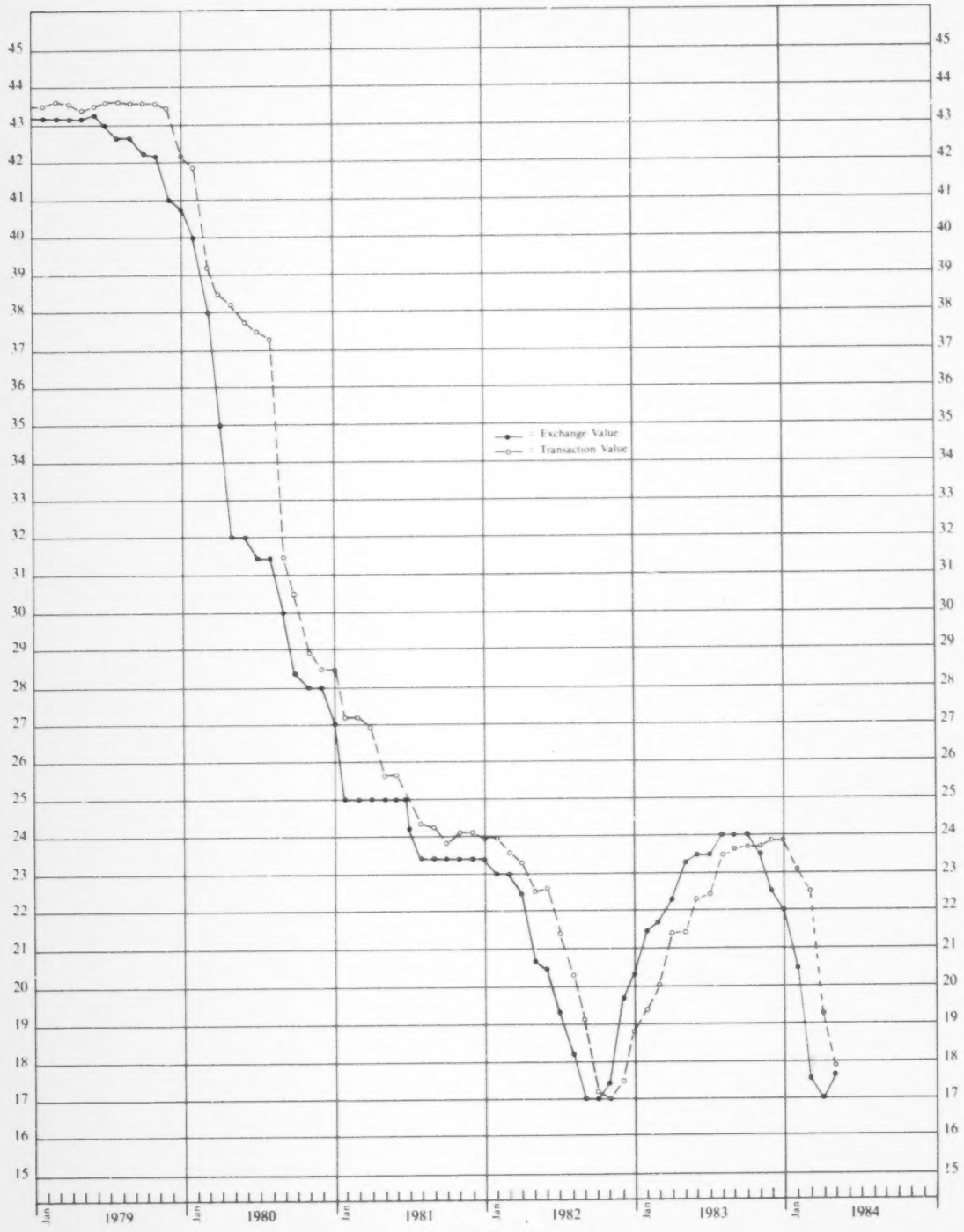
EXCHANGE AND TRANSACTION VALUES SINCE JANUARY 1979

Determined as of the last day of the month indicated



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HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	32.50	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	**17.75**								

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	**17.90**								

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	**0.80**								

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AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry—All Groups[1] (1969=100)	Award Rates of Pay Indexes Australia—Adult Males In Mining Wage Earners, Weekly Rates[2] (1976=100)
1972 Avg.	105.6	71.3
1973 Avg.	124.4	79.0
1974 Avg.	141.9	108.1
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3,4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6P	181.8
Jan 1983	385.7	179.6
Feb 1983	387.5	179.8
Mar 1983	397.4	179.7
Apr 1983	407.6R	180.0
May 1983	415.1R	180.1
Jun 1983	415.9R	180.2
Jul 1983	408.8R	179.9
Aug 1983	403.5R	179.9
Sep 1983	403.4R	179.8
Oct 1983	398.0R	187.6
Nov 1983	396.1R	187.6
Dec 1983	399.6P	187.4
Jan 1984	...	187.6

P = Preliminary R = Revised since last month

[1]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[2]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[3]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.
[4]Annual averages prior to 1979 reflect index base no longer in use.
[5]Monthly data for 1979-82 appear on page 35 of Report 184.

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GOVERNMENT STATISTICS

CANADA

	Industry Selling Price Index: Manufacturing[1] (1971=100)	Wage-earner Data: Average Hourly Earnings (C$)[2]						
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Metal Industries Non-ferrous[4] (SIC 296)	(SIC 296-298)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 370-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	7.35	—	7.67
1980 Avg.	247.2	—	10.59	10.80	—	8.05	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	9.03	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	9.98	—	10.63
1983 Avg.	298.8	—	14.69R	14.30R	—	—	—	11.17R
Jan 1983	292.7	—	14.36	14.35	—	10.72	—	11.06
Feb 1983	293.5	—	14.24	14.28	—	10.74	—	11.06
Mar 1983[8]	295.2	16.79	14.84	14.48	—	10.93	—	11.21
Apr 1983	297.1	16.83	14.40	14.13	11.57	—	10.10	11.02
May 1983	298.5	17.02	14.50	14.10	11.39	—	9.82	10.97
Jun 1983	299.3	17.02	14.60	14.07	11.33	—	9.84	11.05
Jul 1983	300.4	16.48	14.35	13.93	11.70	—	9.83	11.04
Aug 1983	301.3	16.93	14.36	13.89	11.82	—	10.08	11.19
Sep 1983	301.1	17.66	14.90	14.41	11.99	—	10.32	11.29
Oct 1983	301.6	17.73	15.27	14.65	11.76	—	10.03	11.30
Nov 1983	301.7	17.82R	15.29R	14.67R	11.78R	—	10.62R	11.38R
Dec 1983	302.7	17.84R	15.11R	14.66R	11.86R	—	10.60R	11.51R
Jan 1984	304.9	17.74	15.27	14.74	11.91	—	10.84	11.69
Feb 1984	306.3	—	15.09	14.64	11.97	—	10.88	11.57

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)".

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read Total Mining (SIC 051-099)".

[8]Beginning with the April 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to April 1983 only companies employing fewer than 200 wage earners are included in the Wage Earner Data.

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REPUBLIC OF SOUTH AFRICA

	Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Consumer Price Index[2] (1975 = 100)[3]	Producer Price Index All Groups[4] (1975=100)	Total Employment in Mining and Quarrying (Code 35)[5]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[5]
1972 Avg.	8.79	113.3	63.9	623,067	443,933
1973 Avg.	10.51	124.1	72.3	684,743	572,133
1974 Avg.	13.18	138.5	85.3	674,140	761,596
1975 Avg.	16.71	157.2	100.0	639,473	1,003,617
1976 Avg.	19.30	174.7	115.1	671,240	1,212,983
1977 Avg.	23.87	194.4	130.0	712,006	1,420,670
1978 Avg.	27.14	137.2	142.7	664,571	1,537,169
1979 Avg.[6]	30.18	155.3	164.5	692,209	1,830,632
1980 Avg.[7]	35.53	176.7	192.1	714,379	2,279,615
1981 Avg.	41.89	206.5	218.3	728,506	2,820,505
1982 Avg.[8]	47.25	233.5	248.7	707,552	3,246,071
1983 Avg.	51.87	262.2	274.8	696,579	3,644,772
Jan 1983	—	249.0	264.9	688,030	289,075
Feb 1983	—	253.1	267.4	697,089	281,413
Mar 1983	50.35	255.9	269.1	695,976	290,586
Apr 1983	—	257.8	270.9	697,158	286,708
May 1983	—	259.7	274.1	701,712	295,701
Jun 1983	50.51	260.8	273.1	706,933	300,177
Jul 1983	—	262.5	273.7	704,202	314,566
Aug 1983	—	265.6	278.9	698,984	311,789
Sep 1983	52.92	267.3	279.4	696,435	312,264
Oct 1983	—	270.0	281.0	693,225	311,418
Nov 1983	—	271.4	281.6	688,459	317,485
Dec 1983	53.70	273.2	283.7	690,750	333,595
Jan 1984	—	274.7	283.3	—	—
Feb 1984	—	278.4	286.5	—	—
Mar 1984	—	281.9	—	—	—

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. The tonnage-weight index of average working costs per metric ton of gold ore milled for 1983 follows. (Base: March quarter 1982 = 100). See page 16 of Report 178 for the description and calculation of index, and page 24 of Report 178 for figures for 1982.

1983:	January-March	111.2
	April-June	111.9
	July-September	117.4
	October-December	119.6

[2]Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."
[3]For annual averages prior to 1978, April 1970 = 100.
[4]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same.
[5]Bulletin of Statistics, Department of Statistics, Pretoria.
[6]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.
[7]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.
[8]Monthly data for 1979-82 appear on page 39 of Report 184.

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GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
	Industrial Commodities (1967=100)	All Commodities (1967=100)	(1967=100)	(1972=100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1972 Avg.	117.9	119.1	125.3	100.00	4.56	4.59	4.26	3.71
1973 Avg.	125.9	134.7	133.1	105.75	4.84	4.98	4.51	3.91
1974 Avg.	153.8	160.1	147.7	115.08	5.44	5.63	4.88	4.21
1975 Avg.	171.5	174.9	161.2	125.79	6.13	6.24	5.39	4.64
1976 Avg.	182.4	183.0	170.5	132.34	6.76	6.87	5.91	4.96
1977 Avg.	195.1	194.2	181.5	140.05	7.28	7.67	6.43	5.39
1978 Avg.[5]	209.4	209.3	195.4	150.42	8.23	8.56	7.02	5.82
1979 Avg.	236.5	235.6	217.4	163.42	9.27	9.50	7.60	6.32
1980 Avg.	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[6]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.67	13.44	10.58	8.66
Jan 1983	313.9	299.9	293.1	—	12.63	13.33	10.34	8.53
Feb 1983	313.9	300.9	293.2	—	12.66	13.29	10.41	8.56
Mar 1983	313.5	300.6	293.4	212.83	12.48	13.35	10.39	8.60
Apr 1983	312.4	300.6	295.5	—	12.67	13.34	10.43	8.60
May 1983	313.6	301.5	297.1	—	12.55	13.62	10.50	8.60
Jun 1983	315.3	302.4	298.1	214.55	12.66	13.38	10.52	8.63
Jul 1983	316.5	303.2	299.3	—	12.68	13.56	10.58	8.69
Aug 1983	317.3	304.7	300.3	—	12.63	13.46	10.61	8.64
Sep 1983	317.1	305.3	301.8	216.44	12.71	13.47	10.69	8.75
Oct 1983	318.5	306.0	302.6	—	12.78	13.56	10.78	8.73
Nov 1983	318.3	305.5R	303.1	—	12.72	13.56	10.86	8.78
Dec 1983	318.4	306.0	303.5	218.53	12.85	13.34	10.89	8.86
Jan 1984	319.2	308.1	305.2	—	12.78R	13.39R	10.90R	8.89R
Feb 1984	320.4	308.8	306.6	—	12.85P	13.40P	10.89	8.86R
Mar 1984	321.9	311.1	307.3	220.73	—	—	10.89P	8.87P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." 2. All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[5]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[6]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

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